Momentum

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momentum - quantity of motion

$\vec{p} = m\vec{v}$ $\quad [kg \cdot \frac{m}{s}] = [N \cdot s]$ $\quad kg\,\frac{m}{s^2} \cdot s$

$\Delta\vec{p}$ = impulse = $F_{net}\Delta t$ $\quad [N \cdot s]$

(if object accelerates its velocity changes
$\therefore$ $\vec{p}$ changes; net force causes acceleration)

Note

- momentum depends on mass and velocity
- the longer a net force acts, the greater the change in momentum

momentum and collisions

✡ Elastic collisions - both momentum and kinetic energy are conserved (equal before and after)

✡ Inelastic collisions - only momentum is conserved, not E_k

✳ Momentum is always conserved! ✳

✡ Law of Conservation of Momentum

- in an isolated system (no net external forces act) the total momentum before a collision equals the total momentum after.

$$\vec{p}_{before} = \vec{p}_{after}$$

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$$

$$m_1\vec{V}_1 + m_2\vec{V}_2 = m_1\vec{V}_1' + m_2\vec{V}_2'$$

$$m_1\vec{V}_1 + m_2\vec{V}_2 = (m_1+m_2)\vec{V}_{12}' \quad \text{stick together}$$

$$(m_1+m_2)\vec{V}_{12} = m_1\vec{V}_1' + m_2\vec{V}_2' \quad \text{break apart}$$

Types of Problems

Linear collisions
- stick together
- don't stick

} today

2-D collisions
- at 90°
- other than 90°

} tomorrow

Explosions
- objects separate into pieces

Example Problems

① don't stick

$$\vec{P}_{before} = \vec{P}_{after}$$

E +
W −

$$m_1\vec{V}_1 + m_2\vec{V}_2 = m_1\vec{V}_1' + m_2\vec{V}_2'$$

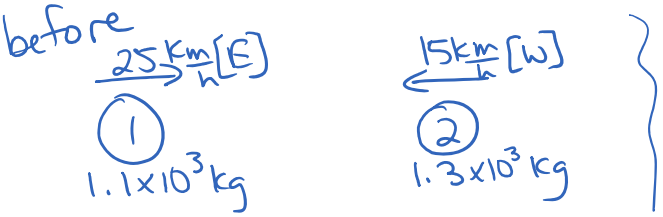
$$(0.25\text{kg})(4.5\tfrac{\text{m}}{\text{s}}) + (0.3\text{kg})(-5\tfrac{\text{m}}{\text{s}}) = (0.25\text{kg})(-2\tfrac{\text{m}}{\text{s}}) + (0.3\text{kg})\vec{V}_2'$$

$$1.13\,\text{kg}\tfrac{\text{m}}{\text{s}} + -1.5\,\text{kg}\tfrac{\text{m}}{\text{s}} = -0.5\,\text{kg}\tfrac{\text{m}}{\text{s}} + 0.3\vec{V}_2'$$

$\vec{V}_2' = +0.42 \frac{m}{s}$ since "+" is east

$\rightarrow 0.42 \frac{m}{s}[E]$

② objects stick



don't need to change to m/s since just finding V_{12} in km/h too

East + West −

$$\vec{P}_{before} = \vec{P}_{after}$$

$$m_1\vec{V}_1 + m_2\vec{V}_2 = (m_1+m_2)\vec{V}_{12}'$$

$$(1.1\times10^3 kg)\left(25\frac{km}{h}\right) + (1.3\times10^3 kg)\left(-15\frac{km}{h}\right) = (2.4\times10^3 kg)\vec{V}_{12}'$$

$\vec{V}_{12}' = +3.3 \frac{km}{h}$ (positive is East)

$\rightarrow 3.3 \frac{km}{h}[E]$

Practice pg 81 #1-3
pg 82 #1-10

#4 pg 82

$m = 1.2\times10^3 kg \leftrightarrow$ time = 1 s

$\Delta V = 5.0\times10^4 \frac{m}{s}$

$F_g = 5.8\times10^7 N$ ← needed force to lift off

impulse: $m\Delta V = F\Delta t$

$(1.2\times10^3 kg)(5.0\times10^4 \frac{m}{s}) = F_{Th}(1 s)$

$F_{Th} = 6.0\times10^7 N$

F_{Th} greater than F_g, so

$F_g = 5.8 \times 10^5 N$ < to lift off

$\therefore$ Thrust (F_{Th}) is greater than F_g, so will lift off.